



POSTAL BOOK PACKAGE 2024

ELECTRICAL ENGINEERING

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CONVENTIONAL Practice Sets

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DIGITAL ELECTRONICS

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Number Systems and Codes

Practice Questions : Level-I

- Q.1** (i) Convert octal 756 to decimal.
 (ii) Convert hexadecimal 3B2 to decimal.
 (iii) Convert the long binary number 1001001101010001 to octal and to hexadecimal.

Solution:

(i) $(756)_8$

$$= 7 \times 8^2 + 5 \times 8^1 + 6 \times 8^0$$

$$= 448 + 40 + 6 = (494)_{10}$$

(ii) $(3B2)_{16}$

$$= 3 \times 16^2 + 11 \times 16^1 + 2 \times 16^0 \quad (\text{put } B = 11)$$

$$= 768 + 176 + 2 = (946)_{10}$$

(iii)

$$\begin{array}{ccccccc} 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 1 & 1 & 0 & 1 & 0 & 1 & 0 & 0 & 0 & 1 \\ \hline & & 1 & & 1 & & 1 & & 5 & & 2 & & 1 & & & & & \end{array}$$

$$= (111521)_8$$

and

$$\begin{array}{ccccccc} 1 & 0 & 0 & 1 & 0 & 0 & 1 & 1 & 0 & 1 & 0 & 1 & 0 & 0 & 0 & 1 \\ \hline & & 9 & & 3 & & 5 & & 1 & & & & & & & \end{array}$$

$$= (9351)_{16}$$

- Q.2** Show the value of all bits of a 12-bit register that holds the number equivalent to decimal 215 in
 (a) binary (b) binary coded octal (c) binary coded hexadecimal and (d) binary coded decimal.

Solution:

(a) Binary

$$(215)_{10} = (11010111)_2$$

In a 12-bit register, it will be stored as: "0 0 0 0 1 1 0 1 0 1 1 1"

(b) Binary Coded Octal

$$(215)_{10} = (0327)_8 = 000 \ 011 \ 010 \ 111$$

(c) Binary Coded Hexadecimal

$$(215)_{10} = (0D7)_{16} = 0000 \ 1101 \ 0111$$

(d) Binary Coded Decimal

In binary coded decimal, each decimal (0 to 9) digit is represented by 4-bit binary code.

$$(215)_{10} = 0010 \ 0001 \ 0101$$

2	215	
2	107	1
2	53	1
2	26	1
2	13	0
2	6	1
2	3	0
	1	1

- Q.3** Consider the addition of numbers with different bases

$$(x)_7 + (y)_8 + (w)_{10} + (z)_5 = (k)_9$$

If $x = 36$, $y = 67$, $w = 98$ and $k = 241$, then z is

Solution:

$$\begin{aligned}
 (36)_7 &= (27)_{10} \\
 (67)_8 &= (55)_{10} \\
 (98)_{10} &= (98)_{10} \\
 (z)_5 &= (z)_5 \\
 (241)_9 &= (199)_{10} \\
 (z)_5 &= (199)_{10} - (27)_{10} - (55)_{10} - (98)_{10} \quad \begin{array}{r} 5 \overline{) 19} \overline{) 4} \\ \underline{3} \end{array} \\
 (z)_5 &= (19)_{10} \\
 (z)_5 &= (34)_5 \\
 \therefore z &= 34
 \end{aligned}$$

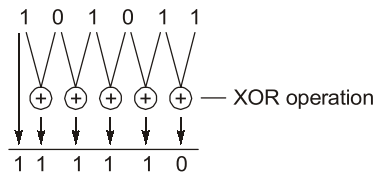
Q4 (a) Convert the below binary code into Gray code.

(i) 101011 (ii) 110110

(b) Convert below gray code into binary
110011

Solution:

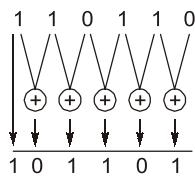
(a) (i) Binary code:



Write the most significant as it is then obtain the remaining bits by doing XOR operation between adjacent bits.

Hence Gray code will be 111110.

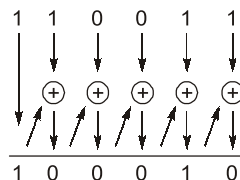
(ii) 110110



Hence Gray code will be 101101

(b) Given Gray code is 110011.

Now to convert it into binary, write most significant bit as it is and then XOR this bit to the next most significant bit and repeat the procedure



Hence result binary code will be $(100010)_2$.

Q5 (a) Represent the 8620 into following codes:

(i) BCD (ii) Excess-3 (iii) 2421

(b) Find 7's complement of the given number $(2365)_7$

Solution:

- (a) (i) Write binary equivalent of each decimal

$$8620 \Rightarrow 1000 \ 0110 \ 0010 \ 0000$$

- (ii)
- Excess-3:**
- For excess 3, add 3 (binary 0011) to each BCD part.

Hence,

$$\begin{array}{cccc} 1000 & 0110 & 0010 & 0000 \\ +0011 & +0011 & +0011 & +0011 \\ \hline 1011 & 1001 & 0101 & 0011 \end{array}$$

- (iii) 2421: It is a weighted binary code

Decimal digit	2	4	2	1
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	1	0	1	1
6	1	1	0	0
7	1	1	0	1
8	1	1	1	0
9	1	1	1	1

There codes are minor image from the given dotted line.

As $(4)_{10}$ and $(5)_{10}$ make complementary pair.Similarly, $(3)_{10}$ and $(6)_{10}$ make the complementary pair.

Hence, 1110 1100 0010 0000.

- (b) For a value/number having a base of
- r
- , then
- r
- 's complement =
- $(r - 1)$
- 's complement + 1

Hence, 7's complement of $(2365)_7$ = 6's complement + 1

$$\begin{array}{r} 6 \ 6 \ 6 \ 6 \\ - 2 \ 3 \ 6 \ 5 \\ \hline 4 \ 3 \ 0 \ 1 \quad \text{6's complement} \\ + 1 \\ \hline 4 \ 3 \ 0 \ 2 \quad \text{7's complement} \end{array}$$

Q.6 Perform the following conversions:

- (i)
- $(3287.5100098)_{10}$
- into octal (ii)
- $(675.625)_{10}$
- into hexadecimal (iii)
- $(A72E)_{16}$
- into octal

Solution:

- (i) To convert
- $(3287.5100098)_{10}$
- into octal:

- Integer part conversion,

$$\begin{array}{r} 8 \overline{) 3287} \\ 8 \overline{) 410 - 7} \\ 8 \overline{) 51 - 2} \\ 8 \overline{) 6 - 3} \\ \hline 0 - 6 \end{array}$$

$$(3287)_{10} = (6327)_8$$

- Fractional part conversion,

$$0.5100098 \times 8 = 4.0800784 \rightarrow 4$$

$$0.0800784 \times 8 = 0.6406272 \rightarrow 0$$

$$0.6406272 \times 8 = 5.1250176 \rightarrow 5$$

$$0.1250176 \times 8 = 1.0001408 \rightarrow 1$$

$$(0.5100098)_{10} = (0.4051...)_8$$

$$\text{So, } (3287.5100098)_{10} = (6327.4051...)_8$$

(ii) To convert $(675.625)_{10}$ into hexadecimal:

- Integer part conversion,

$$\begin{array}{r|l} 16 & 675 \\ \hline 16 & 42 - 3 \\ \hline 16 & 2 - A \\ \hline & 0 - 2 \end{array} \quad \uparrow \quad (675)_{10} = (2A3)_{16}$$

- Fractional part conversion,

$$0.625 \times 16 = 10.000 \rightarrow A$$

$$(0.625)_{10} = (0.A)_{16}$$

$$\text{So, } (675.625)_{10} = (2A3.A)_{16}$$

(iii) To convert $(A72E)_{16}$ into octal:

- Hexadecimal to binary conversion,

$$(A72E)_{16} = (1010\ 0111\ 0010\ 1110)_2$$

- Binary to octal conversion,

$$\begin{aligned} (1010\ 0111\ 0010\ 1110)_2 &= (001\ 010\ 011\ 100\ 101\ 110)_2 \\ &= (123456)_8 \end{aligned}$$

$$\text{So, } (A72E)_{16} = (123456)_8$$

Practice Questions : Level-II

Q7 If $X = 111.101$ and $Y = 101.110$ calculate $X + Y$ and $\left. \begin{matrix} X - Y \\ Y - X \end{matrix} \right\}$ by 2's complement method.

Solution:

Given

$$X = 111.101$$

$$Y = 101.110$$

Now

$$\begin{array}{r} X + Y = 111.101 \\ \quad 101.110 \\ \hline 1101.001 \end{array}$$

For

$$\begin{aligned} X - Y &= X + 2\text{'s complement of } Y \\ &= 111.101 + 010.010 \end{aligned}$$

$$\begin{aligned} \text{Discard the carry} &= \textcircled{1}001.111 \text{ as number will be positive} \\ &= 001.111 = 1.111 \end{aligned}$$

For

$$\begin{aligned} Y - X &= Y + 2\text{'s complement of } X \\ &= 101.110 + 000.011 = 110.001 \end{aligned}$$

\therefore There is no carry generated its a negative number.

\therefore Difference = $-(2\text{'s complement of } 110.001) = -1.111$

Q8 Perform the following addition and subtraction of excess-3 numbers:

(i) $0100\ 1000 + 0101\ 1000$ (ii) $1100\ 1011 - 0100\ 1001$

Check the results obtained, by performing the above operations in decimal format.

Solution:

(i) 0100 1000 + 0101 1000 in excess-3 format:

$$\begin{array}{r}
 0100 \quad 1000 \\
 (+) 0101 \quad 1000 \\
 \hline
 1001 \textcircled{1} 0000 \\
 1 \swarrow \\
 1010 \quad 0000 \\
 (-) 0011 \quad (+) 0011 \\
 \hline
 0111 \quad 0011 \leftarrow \text{Final result in excess-3 format}
 \end{array}$$

There is a carry from lower nibble, which is to be propagated

Add "0011" to lower nibble
Subtract "0011" from higher nibble

Checking the above result in decimal format:

$$\begin{aligned}
 0100 \ 1000 &\xrightarrow{\text{To 8421 BCD}} 0001 \ 0101 \xrightarrow{\text{To decimal}} (15)_{10} \\
 0101 \ 1000 &\xrightarrow{\text{To 8421 BCD}} 0010 \ 0101 \xrightarrow{\text{To decimal}} (25)_{10} \\
 (15)_{10} + (25)_{10} &= (40)_{10} \\
 (40)_{10} &\xrightarrow{\text{To 8421 BCD}} 0100 \ 0000 \xrightarrow{\text{To excess-3}} 0111 \ 0011
 \end{aligned}$$

(ii) 1100 1011 – 0100 1001 in excess-3 format:

$$\begin{array}{r}
 1100 \quad 1011 \\
 (-) 0100 \quad 1001 \\
 \hline
 1000 \quad 0010 \text{ Add "0011" to both the nibbles} \\
 (+) 0011 \quad (+) 0011 \\
 \hline
 1011 \quad 0101 \leftarrow \text{Final result in excess-3 format}
 \end{array}$$

Checking the above result in decimal format:

$$\begin{aligned}
 1100 \ 1011 &\xrightarrow{\text{To 8421 BCD}} 1001 \ 1000 \xrightarrow{\text{To decimal}} (98)_{10} \\
 0100 \ 1001 &\xrightarrow{\text{To 8421 BCD}} 0001 \ 0110 \xrightarrow{\text{To decimal}} (16)_{10} \\
 (98)_{10} - (16)_{10} &= (82)_{10} \\
 (82)_{10} &\xrightarrow{\text{To 8421 BCD}} 1000 \ 0010 \xrightarrow{\text{To excess-3}} 1011 \ 0101
 \end{aligned}$$

Q9 (i) Each of the following arithmetic operations is correct in atleast one number system. Calculate the minimum non-zero base for which the following operations are true.

$$1. \frac{54}{4} = 13 \quad 2. \sqrt{41} = 5 \quad 3. \frac{302}{20} = 12.1 \quad 4. 3 \times 11 = 33$$

(ii) Calculate the minimum non-zero base of x which satisfies the quadratic equation $x^2 - 11x + 22 = 0$, whose roots are $x = 3$ and $x = 6$.**Solution:**(i) 1. Let the base of the expression be ' x '.

$$\text{thus, } \frac{(54)_x}{(4)_x} = (13)_x$$

$$\Rightarrow \frac{5x + 4}{4} = x + 3$$

$$\Rightarrow 5x + 4 = 4x + 12 \\
 x = 8$$

Hence, the minimum non-zero base is equal to '8'.

2. Let the base of the expression be equal to ' x '.

$$\begin{aligned}
 \sqrt{(41)_x} &= (5)_x \\
 \sqrt{4x + 1} &= 5
 \end{aligned}$$

$$4x + 1 = 25$$

$$x = 6$$

Hence, the minimum non-zero base for the expression is equal to 6.

3. Let the base of the expression be equal to x .

$$\frac{(302)_x}{(20)_x} = (12.1)_x$$

$$\frac{3x^2 + 2}{2x} = x + 2 + \frac{1}{x}$$

$$\frac{3x^2 + 2}{2} = x^2 + 2x + 1$$

$$x^2 - 4x = 0$$

$$x = 0, 4$$

Thus, the non-zero base is equal to 4.

4. Let the base of the expression be equal to ' x '.

$$(3)_x \times (11)_x = (33)_x$$

$$3(x + 1) = 3x + 3$$

$$3x + 3 = 3x + 3$$

Thus, the equation is valid for any value of x . So the minimum non-zero base will be equal to $x = 4$.

- (ii) The given quadratic equation,

$$x^2 - 11x + 22 = 0$$

...(i)

The factor of solution are 3 and 6.

Thus, the equation can also be written as

$$x^2 - (\alpha + \beta)x + \alpha\beta = 0$$

$$x^2 - [(3)_b + (6)_b]x + (3)_b \times (6)_b = 0$$

...(ii)

Equating equation (i) and (ii), we get,

$$(3)_b + (6)_b = (11)_b$$

and

$$(3)_b \times (6)_b = (22)_b$$

$$3 + 6 = b + 1$$

$$\therefore b = 8$$

\therefore The minimum non-zero base = 8.

Q.10 What are error-correcting codes? For Hamming code write an expression for describing the location of possible error. Also, find out the value of 'K' for converting BCD code into Hamming code and the bit positions of the resulting Hamming code?

Solution:

- When the digital data is transmitted through the channel, the noise signal changes the original data and false output is obtained at the receiver. To correct this data, it is required to detect the error which is done by error detecting codes and the errors are corrected using error correction codes such as hamming code.
- Hamming codes are a family of linear error-correcting codes. Hamming codes can detect upto two-bit errors or correct one-bit error with detection of uncorrected errors.
- Hamming code is constructed by adding number of parity bits to each group of n -bit information or message in such a way so as to able to locate the bit position in which error occurs. Let us assume that k -parity bits $p_1, p_2, p_3, \dots, p_k$ are added to the n -bit message to form an $(n + k)$ -bit code. The value of ' k ' must be chosen in such a way so as to be able to describe the location of any of the $(n + k)$ possible error bit locations and also "no error" condition consequently, k must satisfy the inequality.

$$2^k \geq n + k + 1$$

...(i)

k -parity checks are performed on selected bits of each code word. Each parity check includes one of the parity bits.

In BCD code, no. of bits = $n = 4$

The value of k must be chosen to satisfy the equation (i) so,

$$2^k \geq 4 + k + 1$$

$$2^k \geq k + 5$$

- Therefore minimum value of $k = 3$. So three parity bits are attached to each of the BCD code for constructing the Hamming code.

Now it will be a 7-bit code with bit positions,

p_1	p_2	n_1	p_3	n_2	n_3	n_4
↓	↓	↓	↓	↓	↓	↓
1	2	3	4	5	6	7

Q.11 (a) Multiply the following number converting to decimal

(i) $(67)_8$ and $(15)_8$ (ii) $(5F)_{16}$ and $(A7)_{16}$

(b) Perform the following operation and obtain the result in binary.

$$(11111111)_2 + (5)_{10}$$

Solution:

(a) (i) $(67)_8$ and $(15)_8$

Converting into binary equivalent

$$\begin{array}{r} 110\ 111 \times 001\ 101 \\ \hline 1\ 10\ 111 \\ 1\ 10\ 111\ XX \\ 110\ 111\ X \\ \hline 10\ 11001011 \end{array}$$

$$\begin{array}{r} \text{(ii)}\ 5F \times A7 \\ 299 \\ 3B6 \times \\ \hline 3DF9 \end{array}$$

$$F \times 7 = (105)_{10} = 16 \times 6 + 9$$

$$5 \times 7 = (35)_{10} + (16)_{10} = (41)_{10} = 16 \times 2 + 9$$

$$F \times A = (150)_{10} = 16 \times 9 + 6$$

$$5 \times A = (50)_{10}$$

$$(50)_{10} + (9)_{10} = (59)_{10} = 16 \times 3 + B$$

$$(9)_{10} + (6)_{10} = (F)_{16}$$

$$(B)_{16} + (2)_{16} = (D)_{16}$$

(b) $(11111111)_2 \div (5)_{10}$

Converting $(5)_{10}$ into binary

$$(5)_{10} = (101)_2$$

$$\begin{array}{r} 11001 \\ 101 \overline{) 1111\ 1111} \\ \underline{101} \\ 101 \\ \underline{101} \\ 00111 \\ 101 \\ 101 \\ 101 \\ X \end{array}$$

$$\begin{aligned} \text{Hence } (1111\ 1111)_2 \div (5)_{10} \\ = 11001 \end{aligned}$$

